



- Homework #3 is due Friday at 11:50am!
- Nighttime observing has 10 more nights.
Check the webpage.
- 1st exam is October 10th— 2 weeks from
Friday.



Outline

- Back to Atoms— for fun
- The Earth as a Planet.
 - magnetic field
 - atmosphere
 - Aurora
- Craters
- The Death of Barney
- Checking out the Moon



Atoms in the Earth

- 1 grain of sand – $\approx 10^{19}$ atoms (about 1 mg)
- Weight of Earth– 6.0×10^{24} kg
- That is $\frac{6.0 \times 10^{24}}{10^{-6}} = 6.0 \times 10^{30}$ Pieces of sand.
- How many atoms?

$$6.0 \times 10^{30} \bullet 10^{19} \approx 10^{49}$$

Atoms in the Solar System



- 1 grain of sand – $\approx 10^{19}$ atoms (about 1 mg)
- Weight of Solar System – 2.0×10^{30} kg
- That is $\frac{2.0 \times 10^{30}}{10^{-6}} = 2.0 \times 10^{36}$ Pieces of sand.
- How many atoms?

$$2.0 \times 10^{36} \bullet 10^{19} \approx 10^{55}$$



Atoms in the Universe

- 1 grain of sand – $\approx 10^{19}$ atoms (about 1 mg)
- Atoms in Solar System – 10^{55}
- In 2nd lecture we said about 10^{22} stars
- How many atoms in observable universe?

$$10^{55} \bullet 10^{22} \approx 10^{77}$$

Our rough estimate is not too far off. But, 10^{79} is more precise.

[illegible]

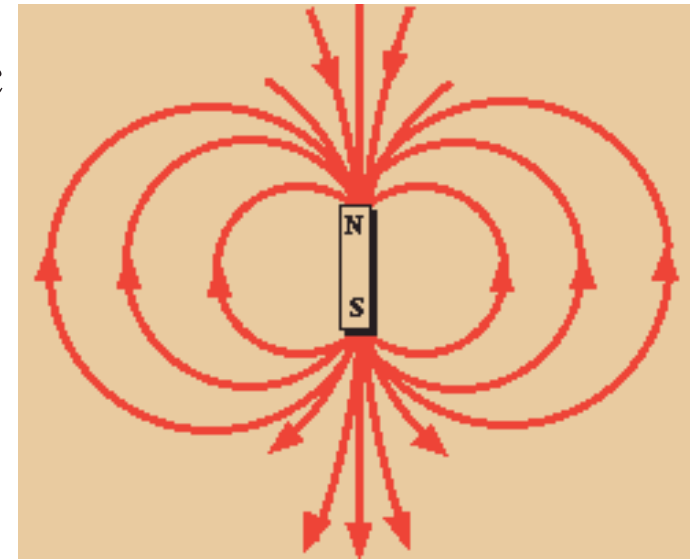


<http://pearl1.lanl.gov/periodic/default.htm>

Earth's Magnetic Field



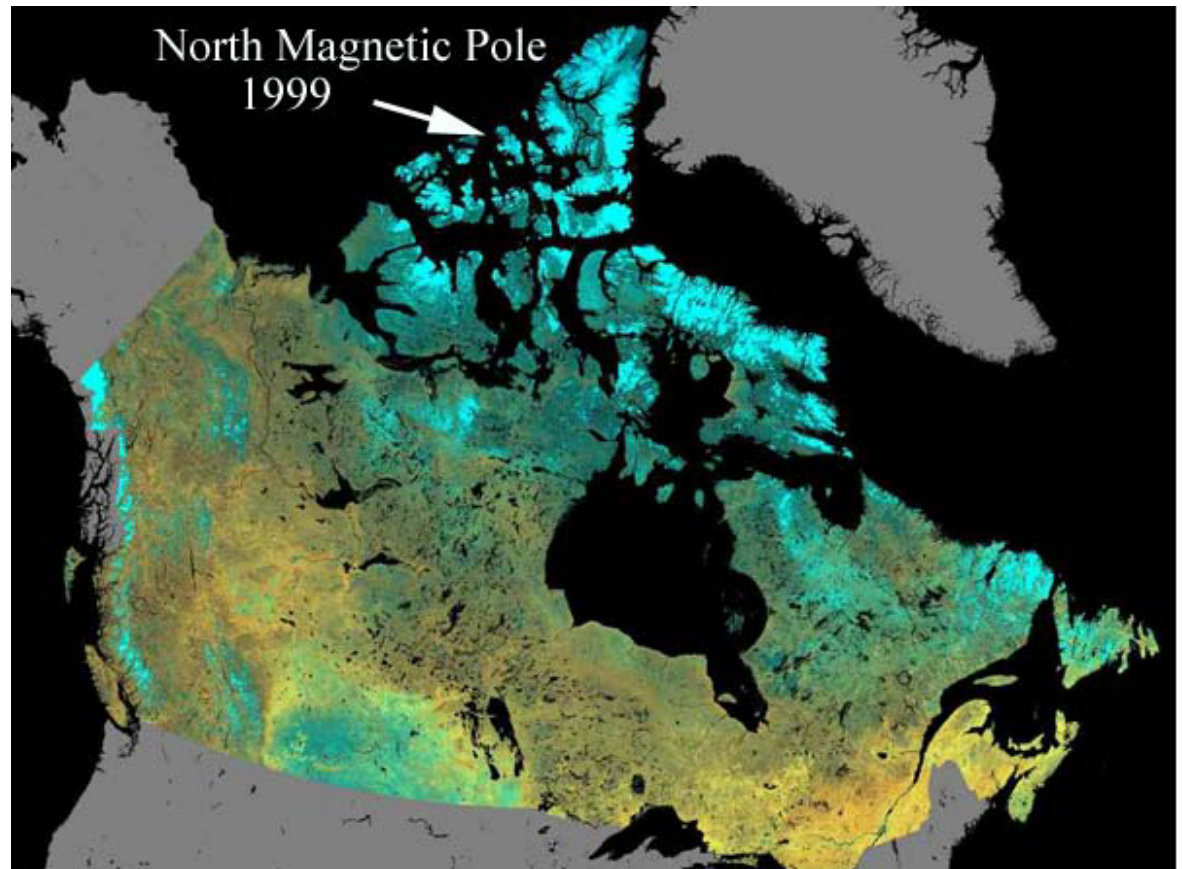
- As you know from using a compass, the Earth has a magnetic field.
- We believe that the convection of the molten iron outer core and the Earth's rotation, creates an electrical current. An electric current produces a magnetic field.
- The “North” of the Earth is slightly offset.
- It irregularly flips direction— last time was 600,000 years ago.
- It protects the Earth from energetic particles— Van Allen Belt



Magnetic North



- Magnetic North can move as much as 40 meters a day.



Aurora from Space



When the Van Allen belts overload with charged particles, they leak through at the poles and cascade down in the Earth's upper atmosphere— sort of like a neon sign



Earth's Atmosphere



- Atmosphere is essential to live, made from Nitrogen and Oxygen— rare in other planets atmosphere
- However, this is the Earth's 3rd atmosphere
 - First was hydrogen and helium from formation
 - Second was from volcanoes— carbon dioxide and some nitrogen (more like Venus)
 - Water helped dissolve the CO₂, and we arrived at the atmosphere we have today (thanks to plants)

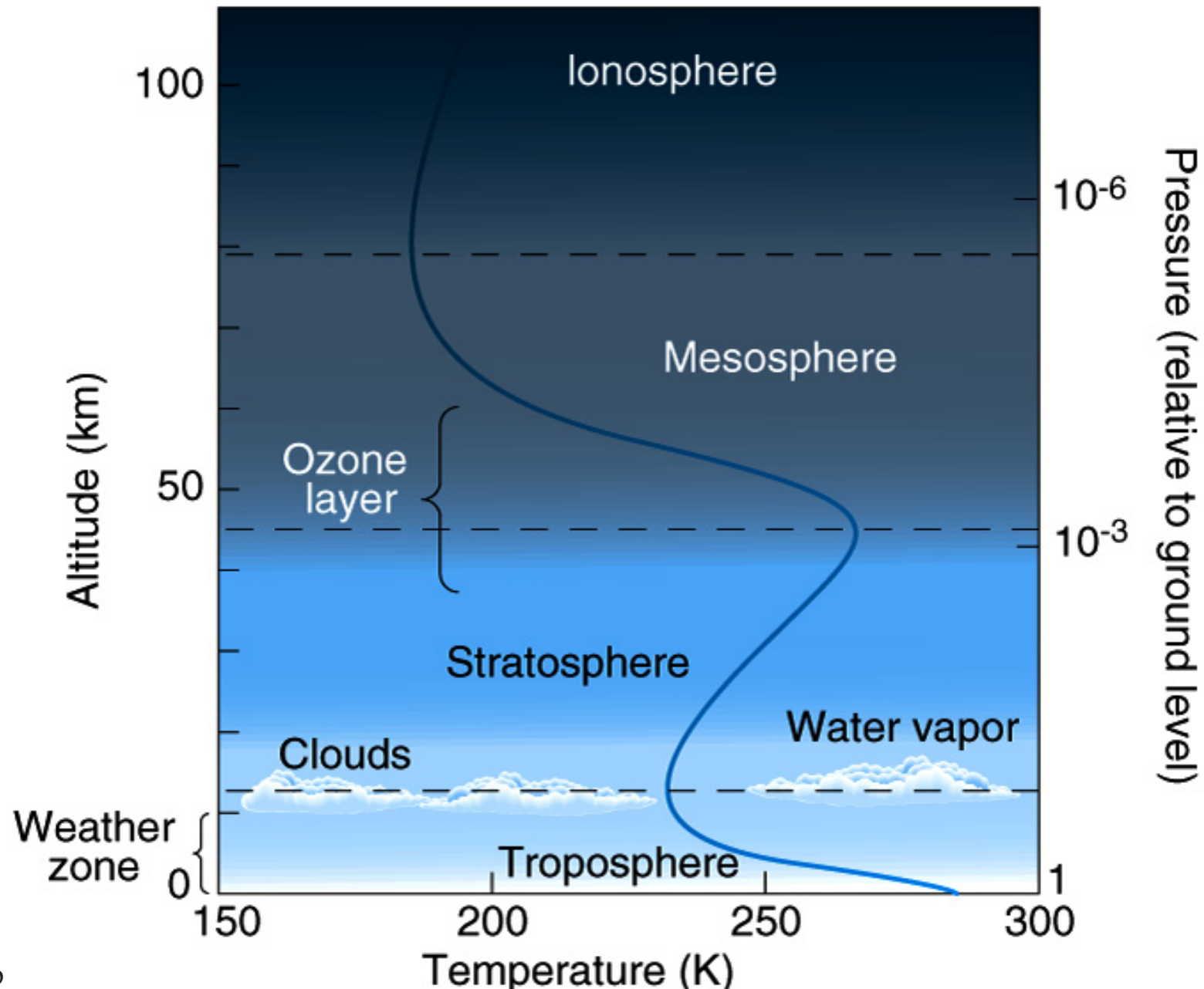
Temperature with Altitude



Does it...

1. Increase
2. Decrease
3. Stay about the same (to within 10%) until space

Layers of the Atmosphere



Ozone Layer



- Ozone is O_3 — three oxygen atoms bound together: created by sunlight
- Absorbs solar ultraviolet light
- Ozone layer (40 km thick so maybe region) has an increase in temperature
- If at the same density as near the surface only a few mm thick
- Human-made chemicals deplete the ozone layer—
This is bad!



The Atmosphere

- What happened to the Earth's first atmosphere— hydrogen and helium?
- Remember Escape Velocity?

the atmosphere is a result of a competition:
heat vs *gravity*



Atmospheres

Heat

Gas atoms in random motion

- hotter = faster
- at each temperature, heavier atoms slower than lighter atoms

http://www.chem.uci.edu/education/undergrad_pgm/applets/canonical/canonical.htm

Planetary Atmospheres



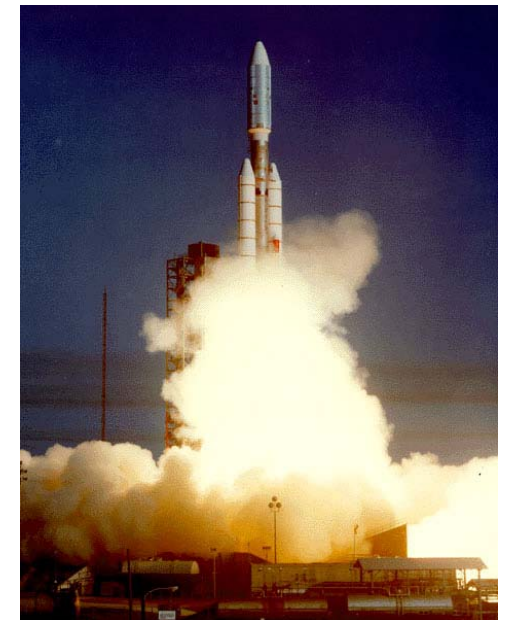
Gravity

- What comes up sometimes comes down
- Example: pop fly: gravity vs inertia, gravity wins
- But faster launch = go higher where gravity weaker



If faster than a critical speed

- leave and never fall back down
- **escape speed**
- Earth: $v_{\text{esc}} = 40,000 \text{ km/hr} = 25,000 \text{ mph}$
- pop fly with this speed does not come back:
- rocket!
- Jupiter: $v_{\text{esc}} = 150,000 \text{ km/hr} = 94,000 \text{ mph}$





Planetary Atmospheres

Bottom line: different outcomes in gravity vs heat struggle

- For Earth and the inner planets
Hotter: H, He atoms faster than escape speed
“leak” away = “evaporate”

Where is this Crater?



Nevada – Nuclear Test 100 kt



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http://www.fas.org/irp/imint/doe_nts_nf121.htm

Moon– Near Side / Far Side



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<ftp://seds.lpl.arizona.edu/pub/images/planets/moon/moon.gif>

<http://antwrp.gsfc.nasa.gov/apod/ap981008.html>

Earth as a Planet– Craters



Question:

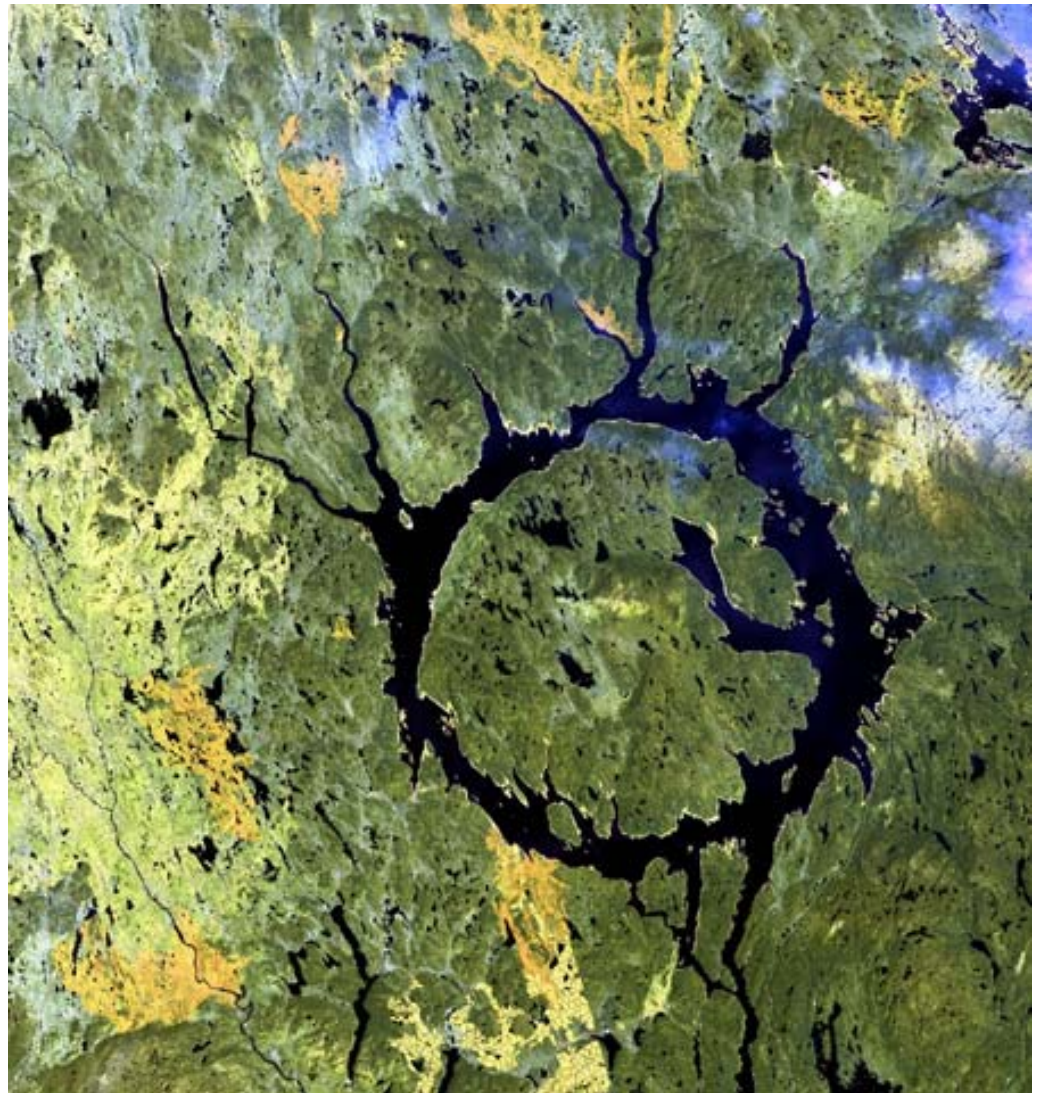
If the Moon is so cratered, why are there so few craters on the Earth– why weren't you jumping craters on your way to 100
Greg Hall?



Earth's Craters



Manicouagan
Crater in Quebec,
Canada— 100 km
wide

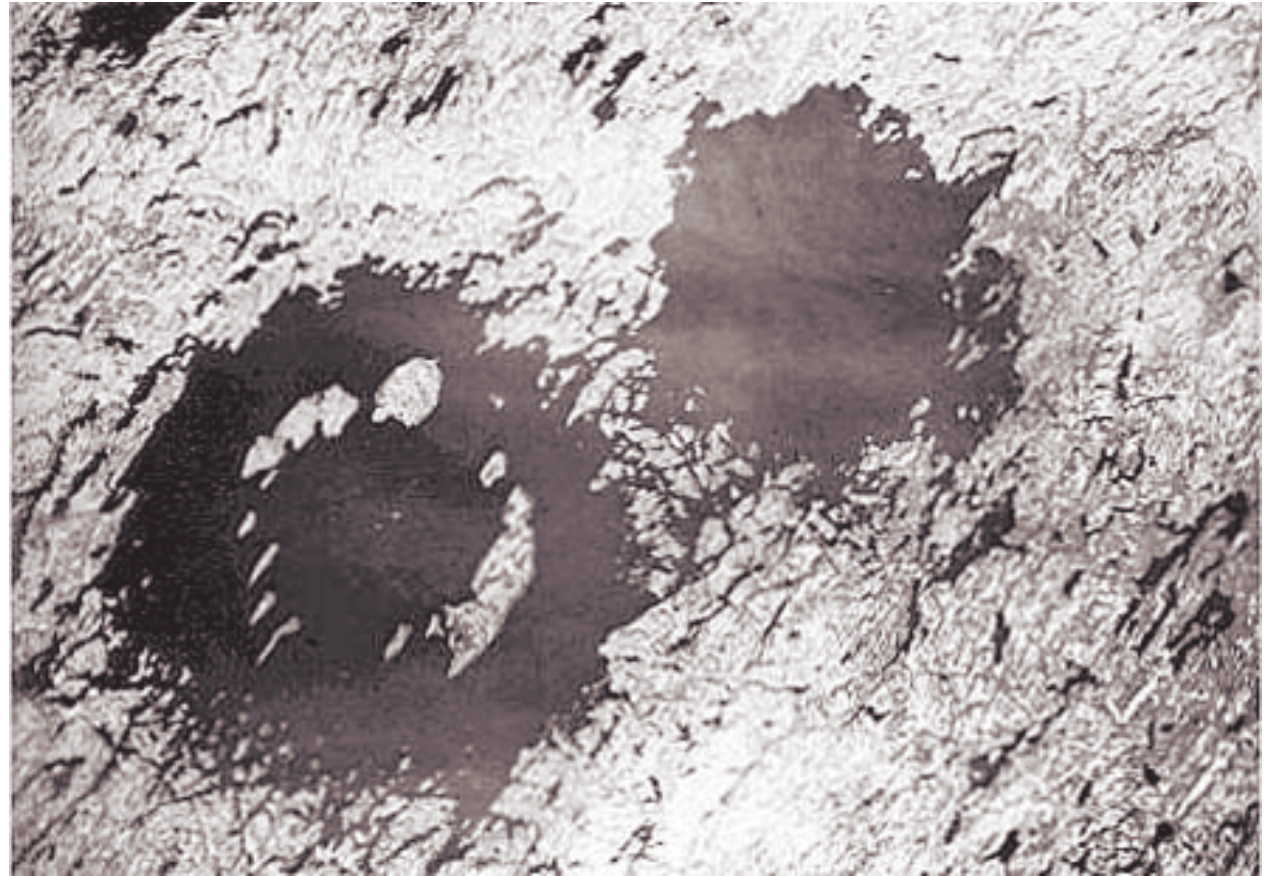


<http://www.unb.ca/passc/ImpactDatabase/images/manicouagan.htm>

Earth's Craters



Clearwater
Lakes also in
Quebec,
Canada— 26
km wide (290
Million years
ago)



<http://www.unb.ca/passc/ImpactDatabase/images/clearwatere.htm>

Earth's Craters



In 1908, a 75 meter meteorite 8 km above the ground of the Tunguska region of Siberia. Trees were incinerated in a 14 km radius from ground zero and were knocked over in a 40 km radius. If this had occurred over a heavily populated area, the effect would have been catastrophic for the people living



<http://www-th.bo.infn.it/tunguska/foto6.htm>

Earth's Craters— Tunguska

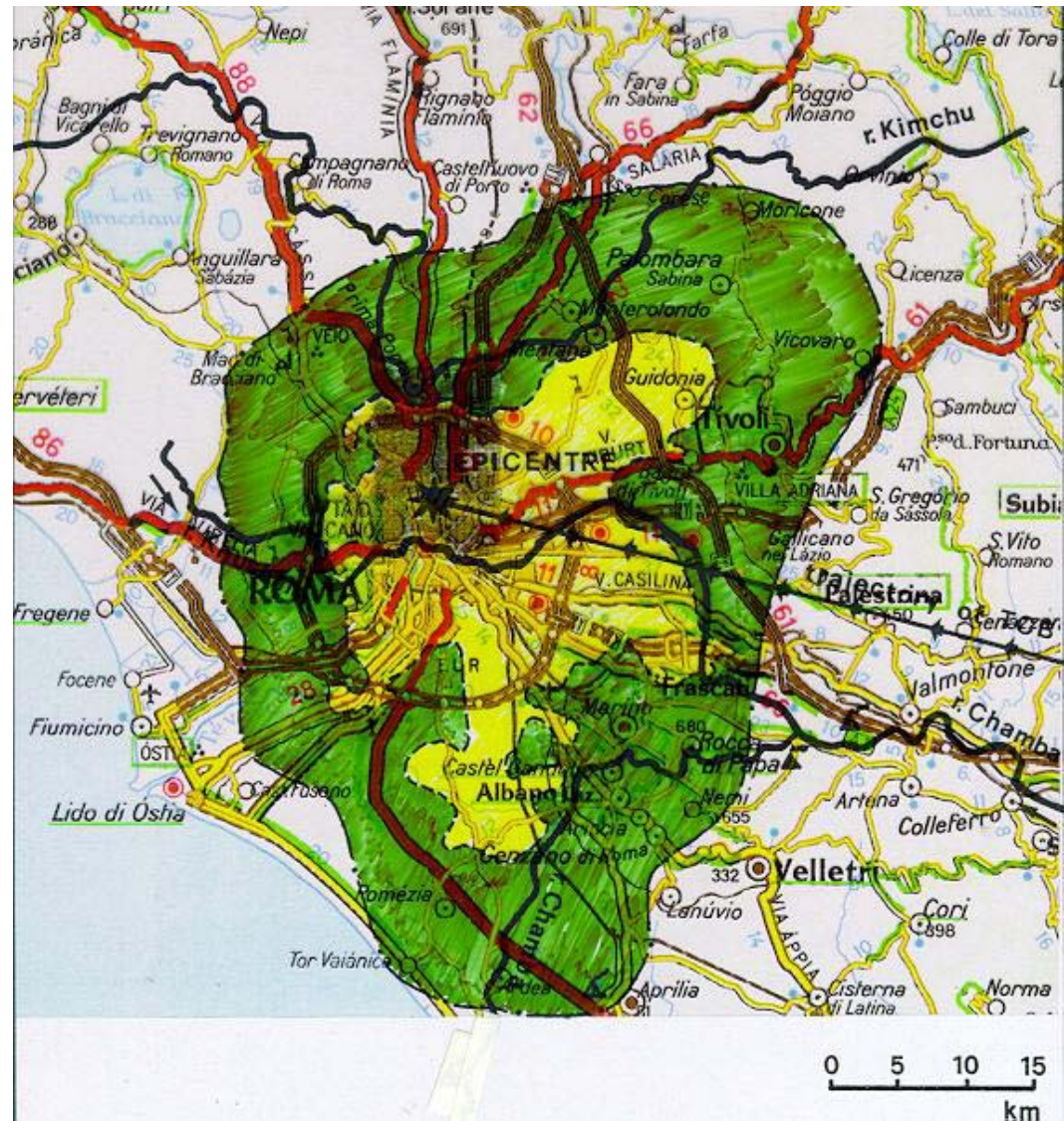


Compare to the city of Rome. Big explosion.

Yellow: area of charred trees.

Green: area of felled trees

Equivalent to 40 megatons of TNT



Earth's Craters— Meteor Crater



Near Winslow,
Arizona.

Occurred 50,000 years
ago with 50 m meteor
struck ground at
25,000 mph.

As much energy as 20
megaton hydrogen
bomb.



Closer to Home



- March 26th, 2003
- Park Forest, IL
- Through roof, hit printer, hit wall



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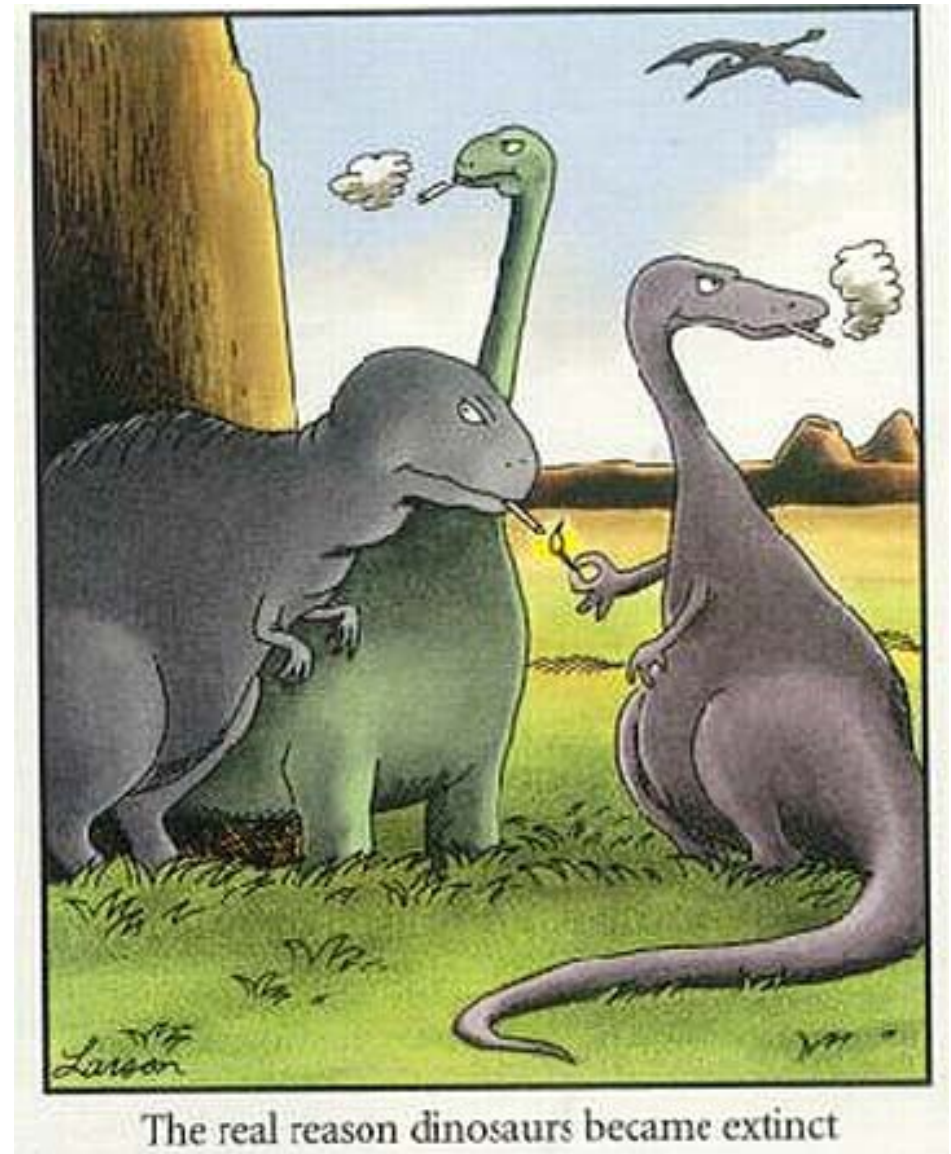
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<http://antwrp.gsfc.nasa.gov/apod/ap030506.html>

What Killed the Dinosaurs?



With all of the evidence of large craters perhaps that contributed to the mass extinction of Dinosaurs.

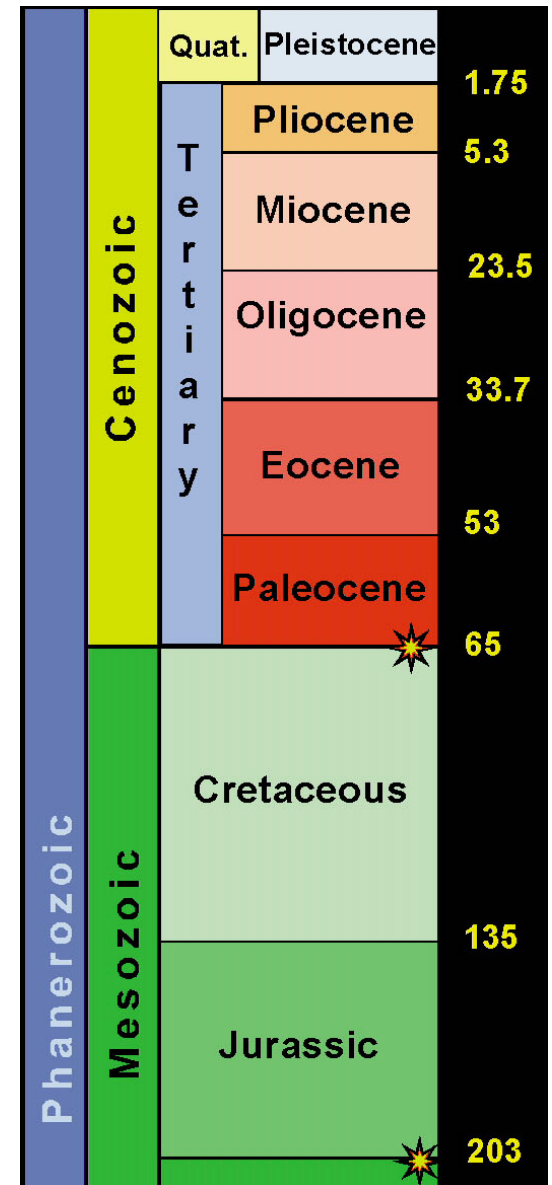


The real reason dinosaurs became extinct

The K-T Boundary



Known mass extinction event between the Cretaceous and Tertiary periods. Not the only one, but the biggest 75% of all species (on land and sea) suddenly were extinct. This was known for 100s of years.



The Iridium Layer



- 1979 it was announced that a layer of Iridium-rich material was found in numerous places in the world
- Iridium is an element that is much more common in asteroids or comets than in Earth's crustal rocks
- This later was deposited 65 million years ago.



Hmm...



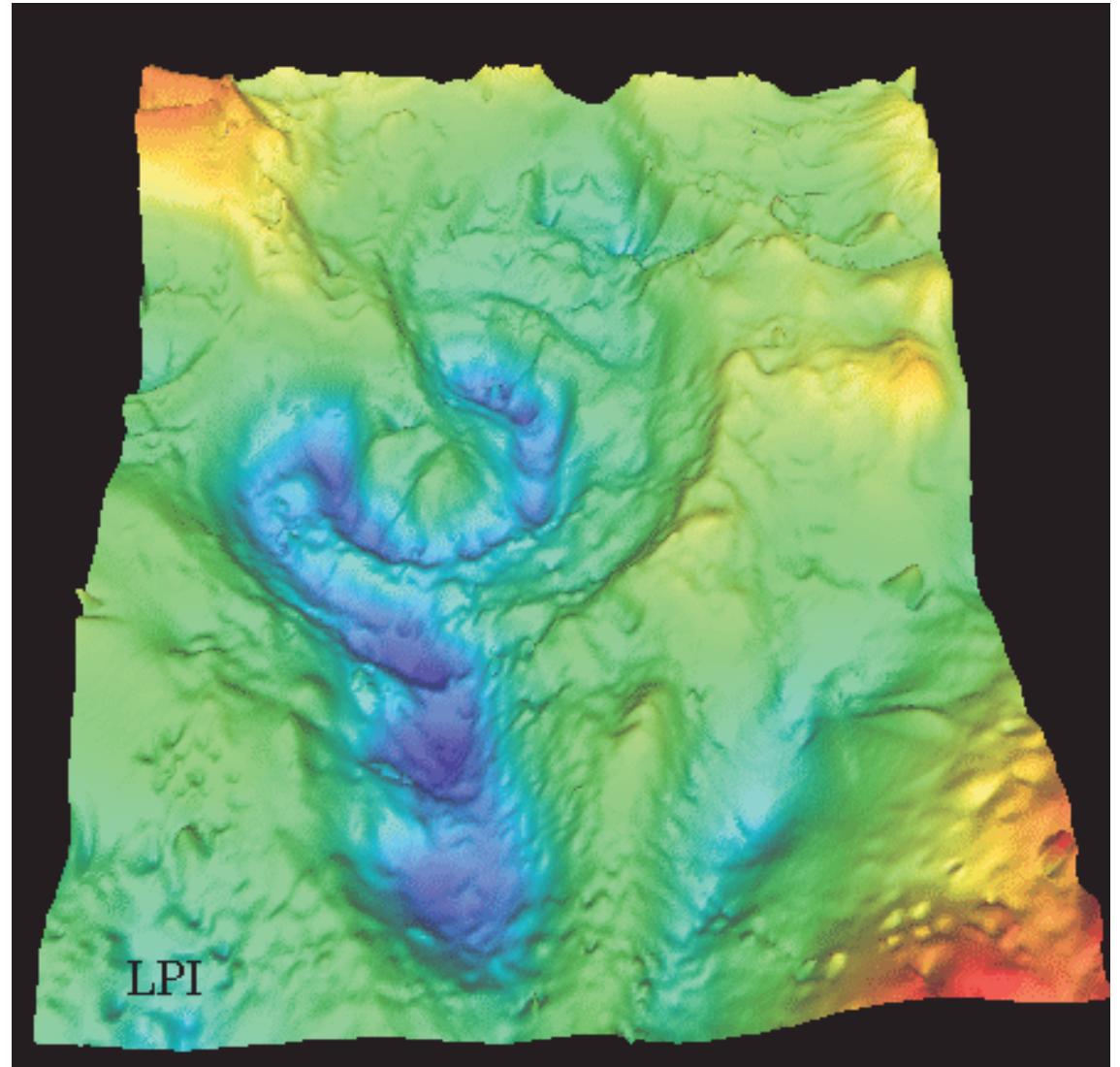
These data suggest the impact of a large object with the Earth 65 million years ago.

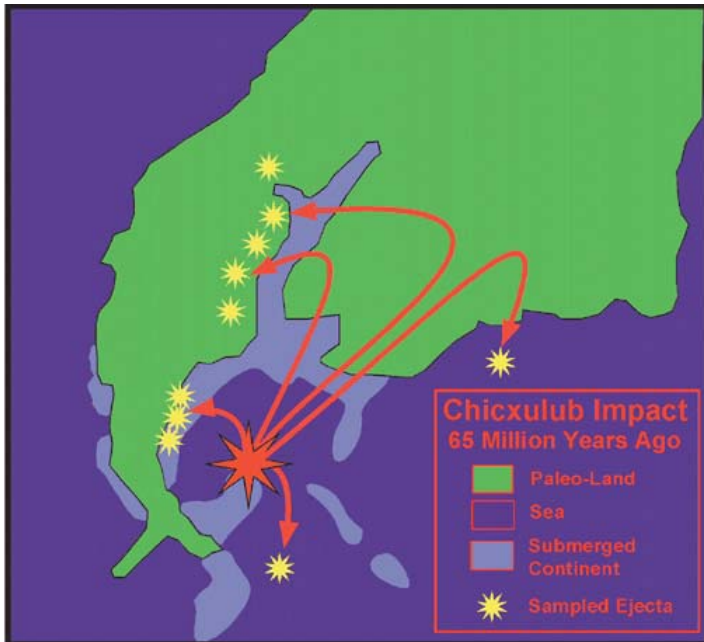




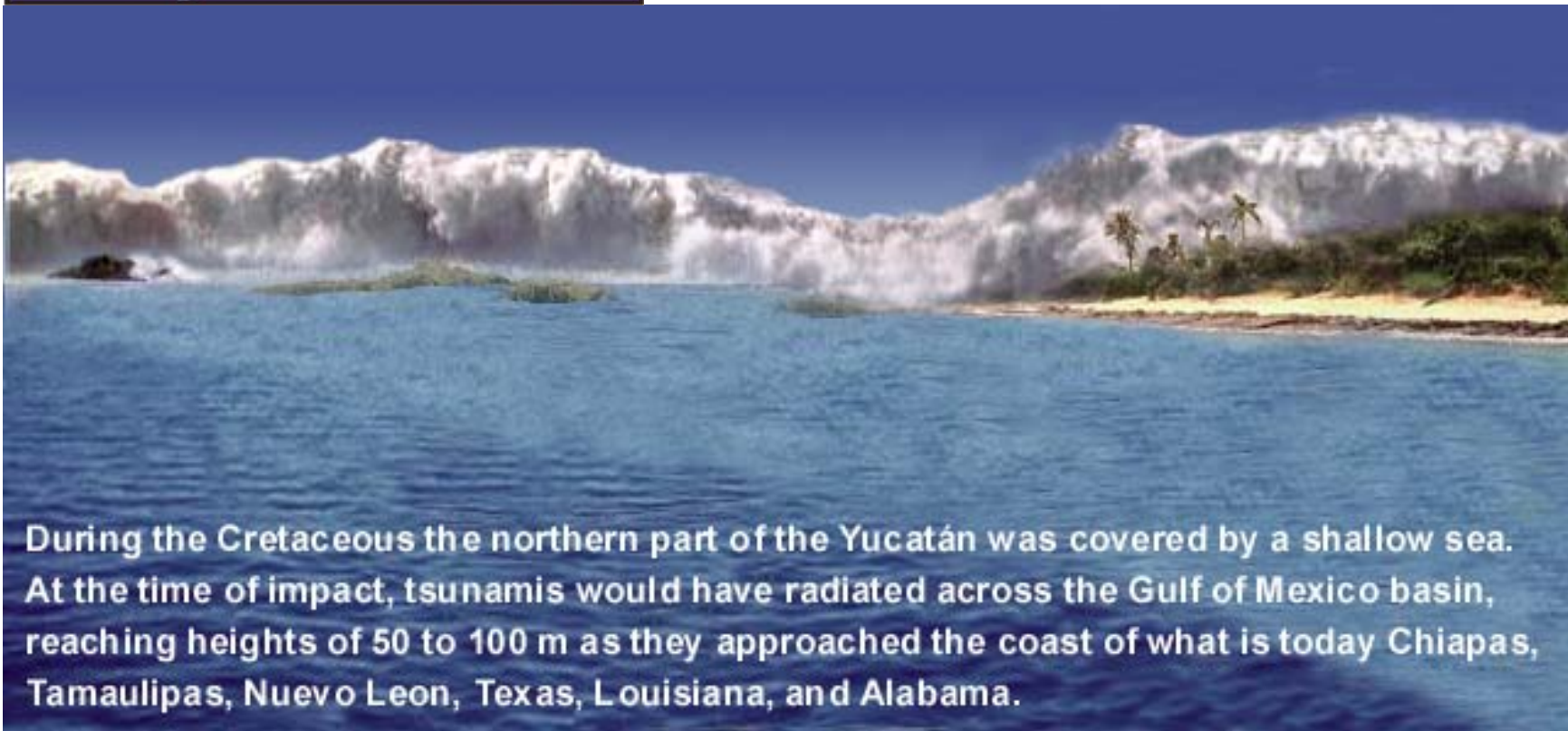
Evidence

- 195 km diameter crater in Mexico—Chicxulub Crater under the Yucatan
- Estimated that it is 65 million years old





Bad Day!

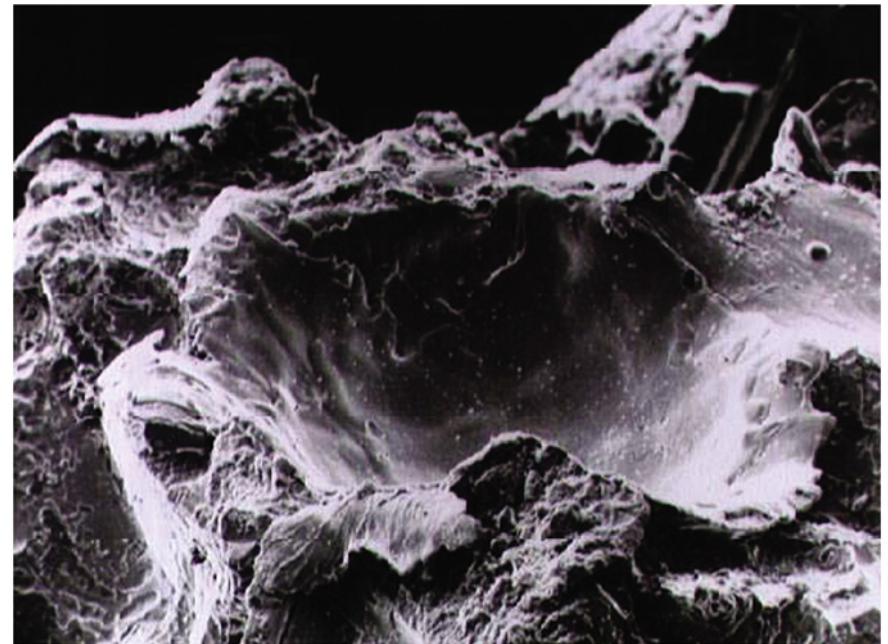


During the Cretaceous the northern part of the Yucatán was covered by a shallow sea. At the time of impact, tsunamis would have radiated across the Gulf of Mexico basin, reaching heights of 50 to 100 m as they approached the coast of what is today Chiapas, Tamaulipas, Nuevo Leon, Texas, Louisiana, and Alabama.

The Surface of the Moon



What is the most distinguishing feature of the Moon?



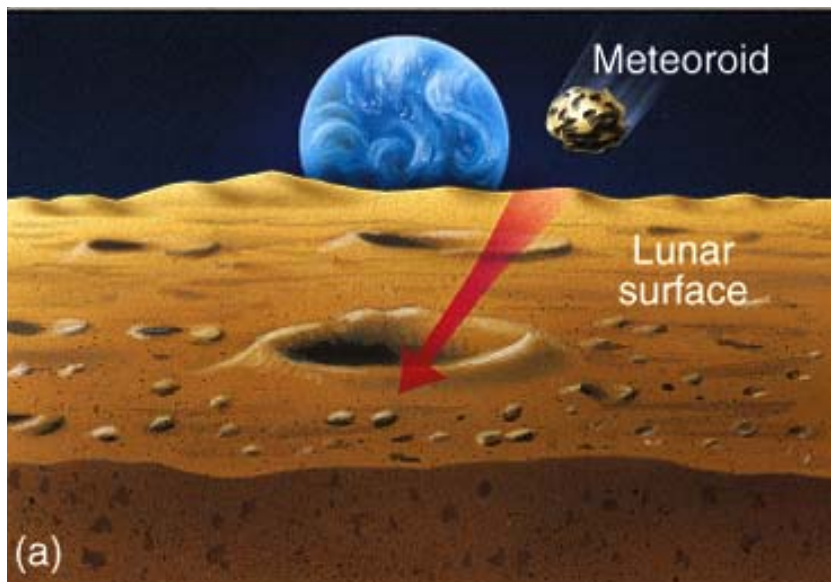
What do most Craters look like?



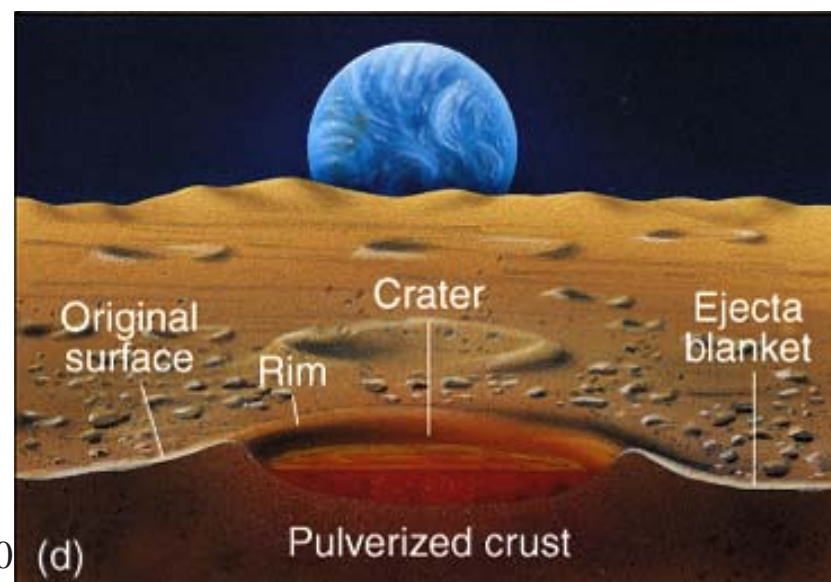
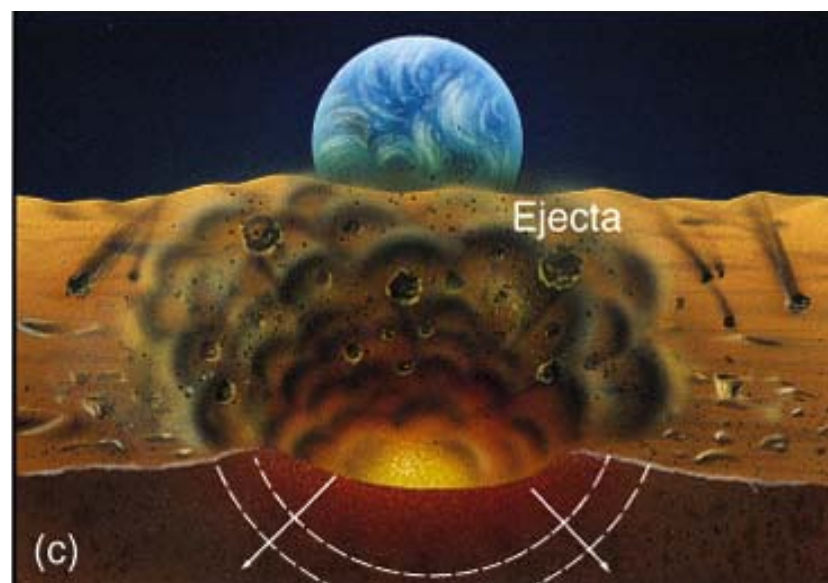
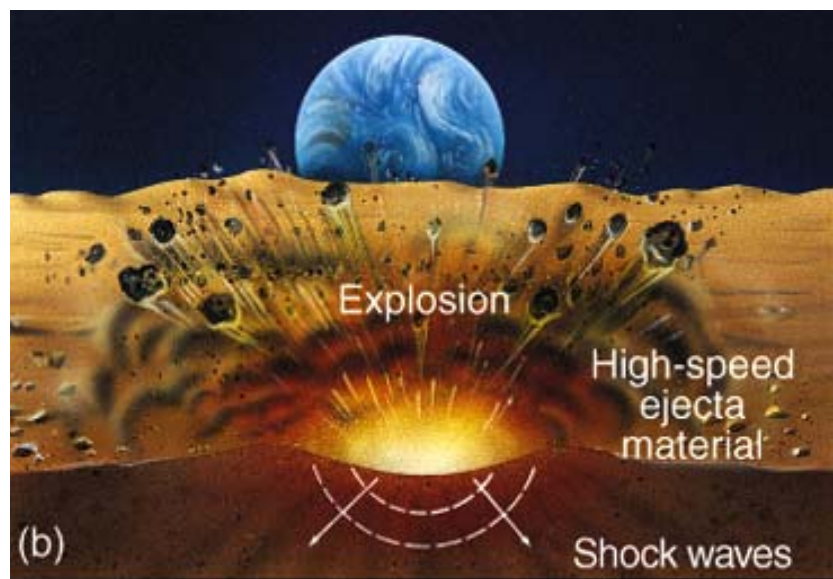
- Notice how they are mostly circular in shape.
- What does that imply about how they were created?



<http://images.jsc.nasa.gov/iams/images/pao/AS11/10075255.jpg>



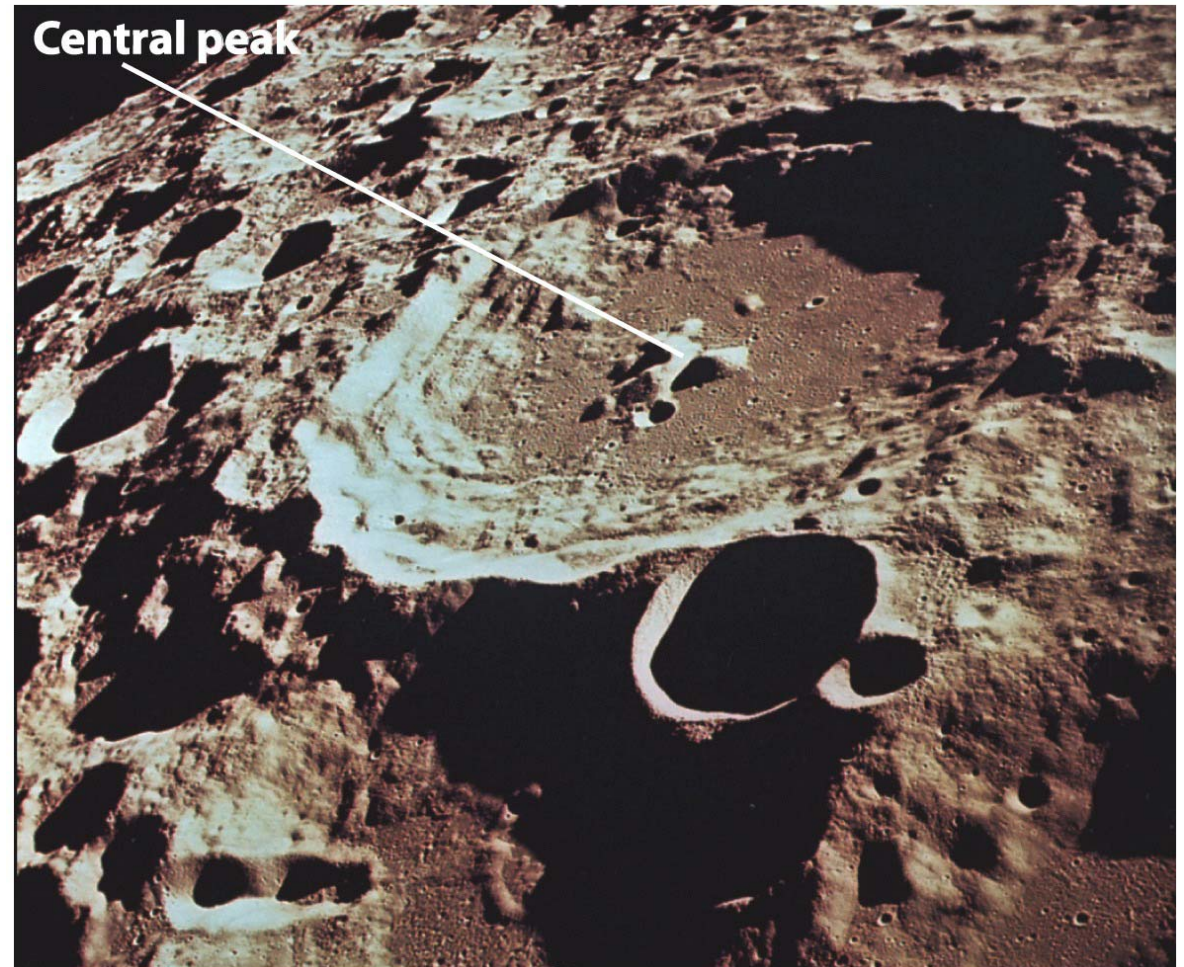
Impact Craters





Larger Craters

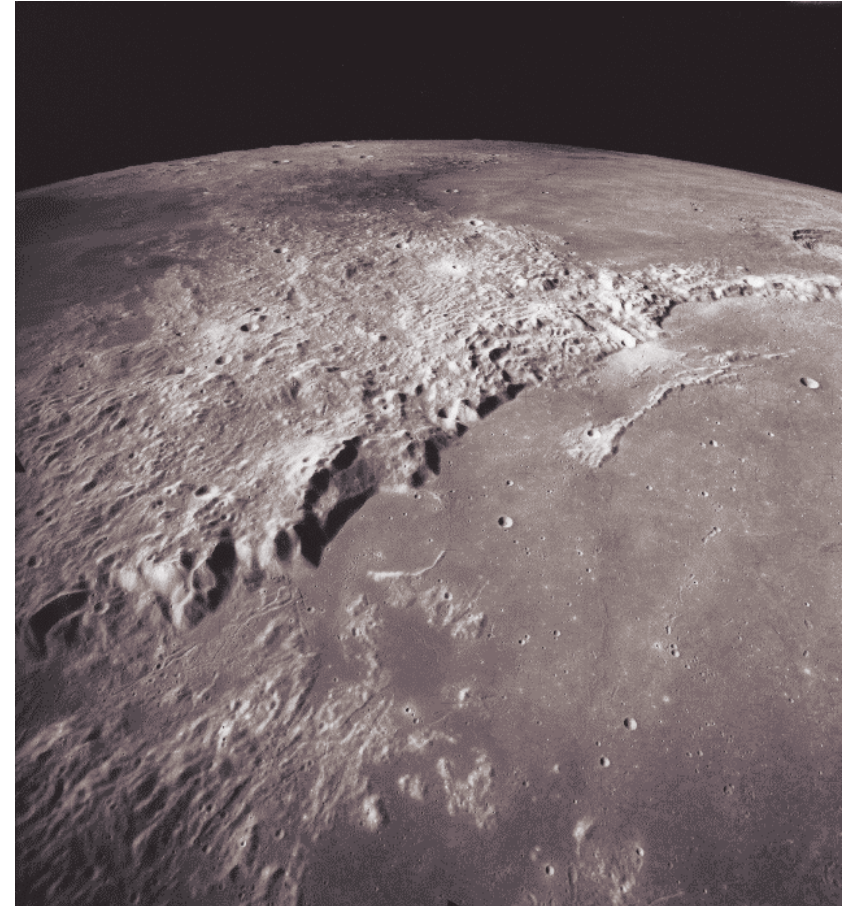
- Central peaks inside the crater
- So much compression initially, the ground rebounds



Maria



- Perhaps next most obvious feature is the dark areas on the Moon
- Singular is Mare (Sea in Latin)— originally thought to be bodies of water



<http://www.lpi.usra.edu/expmoon/Apollo17/A17metric2432.gif>



Maria

Sea of
Tranquillity



Sea of Crisis

Sea of Fertility

www.lpi.usra.edu/expmoon/Apollo17/A17metric2432.gif

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